NATIONAL BUREAU OF STANDARDS REPORT

9806

FIELD STUDY OF FLOOR COVERINGS

Sponsored by

Office of the Chief of Engineers, U. S. Army
Directorate of Civil Engineering, U. S. Air Force
Naval Facilities Engineering Command, U. S. Navy

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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by
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Institute for Applied Technology

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Many of the observations recorded in this report were based on notes taken at various locations by Thomas H. Boone of the National Bureau of Standards and Oray Davis of the Office of the Chief of Engineers, U.S. Army.

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This report gives a summary of observations on test installations of floor coverings, during the period 1955-1968 by representatives of the National Bureau of Standards and the Office of the Chief of Engineers, U.S. Army. Observations were made of 76 installations in 62 locations. Among these locations, 53 were in six U. S. Army posts in the eastern part of the United States between New Jersey and Georgia. Some of the floor covering installations were repeated on the same location because of failures and sometimes there were several test floors in the same site. Of the 76 floor covering installations, 56 were synthetic resin coatings with 52 divided between epoxy, polyester, and polyurethane compositions. Modified hydraulic cement toppings accounted for another 13 installations. There were two more installations with resilient tile and vinyl sheet goods and five with quarry tile. In the quarry tile installations, epoxy and furan resins were used for the bed and joints. Further details are to be found in Tables 1, 2, 3, and 4.

The present report is a sequel to NBS Reports 2485[a], 3660[b], and 8339[c] on previous observations of floor coverings in military installations. Army barracks and mess halls in this report are of the type described in NBS Reports 2485[a] and 8339[c]. By studying various installations over a period of about thirteen years, we have been able to present in this report some valuable practical information. This information will be helpful in studying the causes of failure, in writing specifications, and in recommending which products should or should not be used in various situations. While practical

field studies of this type are necessary, the number of observations is necessarily small and there are a number of variables which cannot be controlled. For example, the largest group of floor coverings reported consists of monolithic resin coatings based on epoxy, polyester, and polyurethane resins. These are further subdivided into brush-on, trowel-on, and thinset terrazzo types of application. The site and usage also varies. The following is an analysis of variables which must be considered in the study and evaluation of floor coverings. Since most of the test installations were monolithic resin coatings, these are emphasized in the analysis. There is much less knowledge and experience with this type of floor covering than with hydraulic cement toppings, resilient flooring, and quarry tile.

Materials used in the floor covering.

In the case of monolithic resin coatings, this includes generic resin types, as epoxy, polyester, and polyurethane. There are variations within these resin types and a valid comparison between types should include several representative brands of each type. Formulations of each resin type also vary as to catalyst, solvents, aggregate, etc.

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a. Thomas H. Boone, Percy A. Sigler, and Hubert R. Snoke, Evaluation of Flooring Materials in Army Installations, May 11, 1953.

b. Percy A. Sigler, Selection and Maintenance of Floors for Naval Shore Establishments, June 17, 1954.

c. Thomas H. Boone and William A. Bender, Performance of Flooring Materials in Military Kitchens, April 30, 1964.

Substrate

Most of the floor coverings reported here were installed over concrete but some were installed over plywood. Some of the concrete floors were slabs on grade and some were suspended. Preparation of the surface to receive the floor covering is important and varies with previous usage and the type of covering. In the case histories reported here, details of surface preparation were not always available. In any case, a good deal depends on the knowledge and skill of the contractor and workmen.

Application of the floor covering.

In the case of monolithic coatings or toppings, the material may be brushed on, rolled on, or troweled. Generally a prime or sealer coat is applied to the concrete or other subfloor. This may be based on a different type of resin from that used in the finish coating. Mixing is important and this varies with the type of coating. Again the knowledge and skill of the applicators is important.

Usage - before and after.

The success of the installation depends on the condition of the subfloor before application and how it is subsequently treated and maintained. What might be adequate preparation for a new, well-cured floor would not suffice for an old floor which was cracked, spalled, on a poor foundation, or subjected to water, soap, starch, grease, and other spillage. Abuse and poor maintenance may also contribute to failures.

One of the values of this field study is to define areas for research. The tables show and analyze failures. In the case of monolithic resin coatings, failures are generally due to loss of bond or adhesion between coating and substrate. Since the substrate is generally concrete, this suggests a laboratory study of adhesion between resin systems and concrete. In the laboratory, variations can be introduced one at a time in order to establish their relevance to the problem. Such studies are in progress and will be reported at a future date.

The tables in this report show more bond failures with epoxy and polyurethane resin compositions than with formulations based on polyester resin. This suggests a comparative study of these three types of resin systems on laboratory concrete or cement mortar specimens. The more detailed portions of the tables indicate the possibility of bond failures being caused by grease, moisture etc. Failures on concrete slabs on grade might be due to hydrostatic pressure. This suggests further experiments on specimens treated with grease, starch, soap etc., wet slabs, slabs subjected to hydrostatic pressure after the coatings are applied etc.

Table 1. SUMMARY OF FLOOR COVERING INSTALLATIONS WITH OBSERVATIONS

Type of Floor Covering	Total	New Inst.	Number of Installations		
			Failures	Fairly Satis.	Satis.
Epoxy monolithic - all types.....	15	1	6	3	5
Brush-on, roll-on.....	2		1		1
Trowel-on industrial.....	10		5	3	2
Thinset terrazzo.....	3	1			2
Polyester monolithic - all types.....	20	2	1	4	12
Trowel-on industrial.....	15	1	1	3	10
Thinset terrazzo.....	5	1		2	2
Polyurethane monolithic - all types..	17		7	5	5
Brush-on, roll-on.....	14		5	4	5
Trowel-on industrial.....	3		2	1	
Various resins.....	4		1	2	1
Trowel-on furan.....	1		1		
Vinyl-acrylic brush-on.....	2			2	
Vinyl trowel-on.....	1				1
Portland cement with additive.....	5		1	2	2
acrylic latex additive.....	2			2	
stryene-butadiene latex additive.	1		1		
asphalt additive.....	2				2
Alumina cement with neoprene latex...	8		1	1	6
Resilient floor coverings.....	2			1	1
Polyester Tile.....	1			1	
Sheet vinyl with welded seams....	1				1
Quarry tile.....	5			2	3
with epoxy bed and joints.....	2			1	1
with furan bed and joints.....	3			1	2

Table 2. LOCATIONS INSPECTED AND TYPES OF FLOOR COVERINGS

Location-Floor No.	Bldg. No.	Type of location	Type of floor covering
		Fort Belvoir, Virginia	
1	T-648	Barracks latrine	Trowel-on epoxy monolithic
2	T-2252 (NC-9)	Barracks latrine	Trowel-on epoxy monolithic
3	T-611	Laundry	
	a. Section next to windows		Trowel-on furan monolithic
	b. 15- by 75-ft. section between washers and driers		Trowel-on polyester monolithic
	c. 75-ft. section between washer and driers		Trowel-on polyester monolithic
4	T-615 (S-3)	Mess hall kitchen	Trowel-on epoxy monlithic
5	T-644 (M-2)	Mess hall kitchen	Trowel-on epoxy monolithic
6	T-733 (K-8)	Mess hall kitchen	Quarry tile with epoxy bed and joints
7	T-725 (K-34)	Mess hall kitchen	
	a. First installation		Trowel-on epoxy monolithic
	b. Second installation		Trowel-on polyester monolithic
8	T-766 (M-21)	Mess hall kitchen	Portland cement with acrylic latex
9	T-1047	Mess hall kitchen	Trowel-on polyurethane monolithic
10	T-1060	Mess hall kitchen	Polyester thinset terrazzo
11	T-1072 (D-10)	Mess hall kitchen	
	a. First installation		Portland cement with styrene-butadiene latex
	b. Second installation		Quarry tile with epoxy bed and joints

Location-Floor No.	Bldg. No.	Type of location	Type of floor covering
12	T-2331	Mess hall kitchen	Quarry tile with furan bed and joints
13	T-2269 (T-22)	Mess hall kitchen	Trowel-on polyester monolithic
14	T-2401 (NM-1)	Mess hall kitchen	Quarry tile with furan bed and joints
15	T-2412 (NM-13)	Mess hall kitchen	Quarry tile with furan bed and joints
16	T-2326 (NN-36)	Showers and dressing rooms in hospital	Alumina cement with neoprene latex
17	T-2363 (NN-55)	Showers and dressing rooms in hospital	Alumina cement with neoprene latex
18	363	Laboratory	Polyester thinset terrazzo
19	247	Entrance between outside door and laboratories	Polyester tile
20	318	Photographic laboratory	Epoxy thinset terrazzo
21	1465	Stair landing in office bldg.	Brush-on polyurethane decorative coating
		Fort Benning, Georgia	
22	385	Bakery	
	a. First installation b. Second installation		Alumina cement with neoprene latex Alumina cement with neoprene latex
23	2100	Barracks latrine and shower room	Polyurethane brush-on coating
24	2311	Barracks latrine and shower room	Polyurethane brush-on coating
25	2312	Barracks latrine and shower room	Polyurethane brush-on coating
26	2313	Barracks latrine and shower room	Polyurethane brush-on coating
27	3157	Mess hall kitchen	Trowel-on polyester monolithic

Location-Floor No.	Bldg. No.	Type of location	Type of floor covering
28	3183	Barracks latrine and shower room	Vinyl-acrylic brush-on coating
29	3187	Barracks latrine and shower room	Vinyl-acrylic brush-on coating
30	3538	Barracks latrine	Brush-on polyurethane coating
31	3411	Barracks latrine and shower room	Trowel-on polyester monolithic
32	3483	Barracks latrine and shower room	Trowel-on polyester monolithic
33	5341	Barracks latrine and shower room	Trowel-on polyester monolithic
34	5343	Barracks latrine and shower room	Trowel-on polyester monolithic
35	5344	Barracks latrine and shower room	Trowel-on polyester monolithic
36	2113	Mess hall kitchen	Alumina cement with neoprene latex
37	2520	Mess hall kitchen	Trowel-on polyester monolithic
		Fort Dix, New Jersey	
38	S-3123	Meat cutting plant	Trowel-on polyester monolithic
39		Laundry	Trowel-on polyester monolithic
		Fort Jackson, South Carolina	
40	1423	Barracks latrine and shower room	Trowel-on polyester monolithic
41	1433	Barracks latrine and shower room	Trowel-on polyester monolithic

Location-Floor No.	Bldg. No.	Type of location	Type of floor covering
		Fort George G. Meade, Maryland	
42	T-2250	Laundry	
		a. 15- by 20-ft. area next to windows	
		(1) First installation	Brush-on polyurethane coating
		(2) Second installation	Trowel-on polyurethane monolithic
		b. 34-ft. long area, third bay from windows	
		(1) First installation	Brush-on epoxy coating
		(2) Second installation	Trowel-on polyurethane monolithic
43	T-309	Mess hall kitchen	Trowel-on epoxy monolithic
44	T-2156	Mess hall kitchen	Trowel-on epoxy monolithic
45	T-2214	Storeroom	Portland cement with asphalt
46	T-2215	Plumbing shop	Portland cement with asphalt
		Fort Myer, Virginia	
47	247B	Stairs outside barracks	Brush-on polyurethane coating
48		Walk ramp outside commissary	Trowel-on epoxy monolithic
49	237	Fire station	Brush-on polyurethane decorative coating
50	404	Mess hall kitchen	Trowel-on epoxy monolithic
51	602	Mess hall kitchen	Portland cement with acrylic latex
52	14B	Kitchen in residence	Brush-on polyurethane decorative coating
53	436B	Kitchen in residence	Brush-on polyurethane decorative coating

Location-Floor No.	Bldg. No.	Type of location	Type of floor covering
		National Institutes of Health, Bethesda, Maryland	
54	a. 10	Clinical Center, Intensive Care Unit	Alumina cement with neoprene latex
	b. 10a	Clinical Center, Circular Operating Wing	Alumina cement with neoprene latex
55	14D	Animal operating rooms and hall	Thinset epoxy terrazzo
56	14G	Animal clean rooms, operating rooms	
	a. Rms. 110,112		Vinyl sheet goods with welded seams
	b. Room 113		Thinset epoxy terrazzo
	c. Room 114		Brush-on polyurethane coating
	d. Room 115		Trowel-on epoxy monolithic
	e. Room 116		Trowel-on vinyl monolithic
	f. Room 117		Roll-on epoxy coating
	g. Center corridor		Alumina cement with neoprene latex
		National Naval Medical Center, Bethesda, Maryland	
57	8	Operating suite	Alumina cement with neoprene latex terrazzo
		Walter Reed Army Medical Center, Washington, D. C.	
58	40	Laboratory glassware washing facility	Brush-on polyurethane decorative coating
59	1D	Concrete sun deck in hospital	Polyester thinset terrazzo
		Walter Reed AMC Annex, Forest Glen, Maryland	
60	142	Recreation building, pool room	Brush-on polyurethane decorative coating
61		Meat cutting plant	Polyester thinset terrazzo
		American Airlines Terminal, Washington National Airport	
62		Lobby and offices etc.	Polyester thinset terrazzo

Table 3. OBSERVATIONS ON VARIOUS TYPES OF FLOOR COVERINGS

EPOXY COATINGS (15)

Brush-on or roll-on type (2)

Failure: (1)
Laundry - No. 42.b. (1)

Satisfactory installation: (1)
Clean room - No. 56.f.

Trowel-on industrial type (10)

Failures: (5)
Barracks latrine - No. 1
Mess hall kitchens (4) - Nos. 4, 5, 7.a, 43

Fairly satisfactory installations: (3)
Mess hall kitchens (2) - Nos. 44, 50
Walk ramp - No. 48

Satisfactory installations: (2)
Barracks latrine - No. 2
Animal room - No. 56.d.

Thinset terrazzo (3)

New installation: (1)
Laboratory - No. 20

Satisfactory installations: (2)
Animal rooms (2) - Nos. 55, 56.b.

POLYESTER COATINGS (20)

Trowel-on industrial type (15)

Failure: (1)
Meat cutting plant - No. 38

New installation: (1)
Mess hall kitchen - No. 7.b

Fairly satisfactory installations: (3)
Laundry - Nos. 3.b., 3.c.
Mess hall kitchen - No. 37

Satisfactory installations: (10)
Barracks latrines (7) - Nos. 31-35, 40, 41
Laundry - No. 39
Mess hall kitchens (2) - Nos. 13, 27

Thinset terrazzo (5)

New installation: (1)
Airline terminal - No. 62

Fairly satisfactory installations: (2)
Concrete sun deck - No. 59
Laboratory - No. 18

Satisfactory installations: (2)
Mess hall kitchen - No. 10
Meat cutting plant - No. 61

POLYURETHANE COATINGS (17)

Brush-on or roll-on type (14)

Failures: (5)
Barracks latrines (4) - Nos. 23-26
Laundry - No. 42.a. (1)

Fairly satisfactory installations: (4)
Laboratory glassware washing facility - No. 58
Fire station - No. 49
Stair landing - No. 21
Recreation building - No. 60

Satisfactory installations: (5)
Barracks latrine - No. 30
Clean room - No. 56.c.
Residences - kitchens (2) - Nos. 52, 53
Stairs outside barracks - No. 47

Trowel-on coatings (3)

Failures: (2)
No. 42a (2) and 42b (2)

Fairly satisfactory installation: (1)
Mess hall kitchen - No. 9

VARIOUS RESIN COATINGS (4)

Failures: (1)

Trowel-on furan coating in laundry - No. 3.a.

Fairly satisfactory installations: (2)

Vinyl-acrylic brush-on coatings in barracks latrines (2) - Nos. 28, 29.

Satisfactory installation: (1)

Vinyl trowel-on coating in clean room - No. 56.e.

CONCRETE FLOOR TOPPINGS BASED ON PORTLAND CEMENT AND ADDITIVES (5)

Acrylic latex additive (2)

Fairly satisfactory installations: (2)
Mess hall kitchens - Nos. 8, 51

Styrene-butadiene latex additive (1)

Failure:
Mess hall kitchen - No. 11.a.

Asphalt additive (2)

Satisfactory installations: (2)
Storeroom (No. 45) and plumbing shop (No. 46)

CONCRETE FLOOR TOPPINGS BASED ON ALUMINA CEMENT AND NEOPRENE LATEX ADDITIVE (8)

Failure: (1)
Bakery - No. 22

Fairly satisfactory installation (1)
Operating suite - No. 57

Satisfactory installations: (6)
Mess hall kitchen - No. 36
Showers and dressing rooms in hospital (2) - Nos. 16, 17
Intensive care unit and Circular operating wing (2) - No. 54a, b.
Center corridor between clean rooms - No. 56.g.

RESILIENT FLOOR COVERINGS (2)

Fairly satisfactory installation: (1)
Polyester tile in entrance between outside door and laboratories - No. 19

Satisfactory installation: (1)
Vinyl sheet goods with welded seams in clean room - No. 56.a.

QUARRY TILE (5)

With epoxy bed and joints (2)

Fairly satisfactory installation: (1)
Mess hall kitchen - No. 6

Satisfactory installation: (1)
Mess hall kitchen - No. 11.b

With furan bed and joints (3)

Fairly satisfactory installation: (1)
Mess hall kitchen - No. 15

Satisfactory installations: (2)
Mess hall kitchens - Nos. 12, 14

Table 4. REPORTS ON INDIVIDUAL INSTALLATIONS

EPOXY COATINGS

Brush-on or Roll-on Type

No. 42.b.(1). Laundry at Fort George G. Meade, Md., third bay from windows, first installation, 1964. (The second installation, 42.b.(2), was a polyurethane coating.)

The concrete floor had become eroded and spalled due to impact from heavy equipment, rolling friction of steel wheels, and the action of hot water, starch, and detergents. The floor was acid etched, rinsed with water, and dried. A solvent-based epoxy primer was rolled on. Cracks, holes, and joints were filled with an epoxy patching compound. Three 10-mil coats of gray epoxy composition were rolled on. After about a month, the floor was removed because of poor bond. Some of the floor coating had already peeled off.

No. 56.f. Animal room - "clean room", National Institutes of Health, Bethesda, Md., 1966. Concrete slab on grade.

Three coatings of epoxy composition were rolled on over a rough polyester coating. Total thickness about 20 mils. After about a year the coating seemed to be in satisfactory condition.

Trowel-on industrial type

No. 1. Barracks latrine at Fort Belvoir, Va., 1968. Concrete slab on grade.

A previous epoxy coating was removed, revealing old paint and a rough surface in the center of the room. A trowel-on epoxy coating was applied to the floor apparently while the room was cold (poorly heated during January). After about a week there were blisters and cracks all over the floor.

No. 2. Barracks latrine at Fort Belvoir, Va., 1959-1968

A 1/8-inch trowel-on coating was installed over a latex coating, which had been installed over a plywood subfloor. Pre-treatment consisted of a primer coat and a glass mat. A surface coating was applied over the trowel-on topping. After more than 8 years service the floor was still in good condition.

No. 4. Mess hall kitchen at Fort Belvoir, Va., 1959-1962.

A 3/16-inch trowel-on coating was applied over concrete, with a pretreatment consisting of a primer coat and a glass mat. A surface coat was applied over the trowel-on topping. After a few weeks the coating started to separate from the concrete and became soft. After a year the top coat was worn off around the dishwashing area. Finally the bond between coating and concrete failed completely around the stoves and drains. The floor was removed after about three years.

No. 5. Mess hall kitchen at Fort Belvoir, Va., 1959-1962.

The concrete subfloor had badly eroded areas at all drains and a few cracks. Grease spots were cleaned with solvent and a solvent-based primer was brushed on. The epoxy coating was troweled on over the primer. The floor gradually disintegrated over a three year period and a large area around the drain broke loose.

No. 7.a. Mess hall kitchen at Fort Belvoir, Va., 1959-1965.

An epoxy coating about 1/8-inch thick was troweled on over concrete. After about a year the coating loosened under the sink, near the range, and at the dishwashing area. This was attributed to grease on the original surface. After about six years the coating was worn and bare concrete showed at three small spots.

No. 43. Mess hall kitchen at Fort George G. Meade, Md.

An epoxy coating had peeled off in large sections during approximately three years service.

No. 44. Mess hall kitchen at Fort George G. Meade, Md., 1964. Concrete slab on grade.

The original wooden floor had been removed and the space had been graded with a compacted fill. A concrete floor was then poured over the fill. Subsequently an epoxy coating was troweled on. This coating proved to be hard to clean.

No. 50. Mess hall kitchen at Fort Myer, Va., 1959-1960.

An epoxy coating was applied over a concrete floor in a dishwashing area, about 200 sq. ft. The concrete surface was acid etched and then a sealer coat was applied. A red epoxy coating was troweled on about 1/4-inch thick. After 24 hours a red pigmented skim coat was applied. After 16 months there was no sign of bond failure or erosion, but the floor was unattractive and there were a number of chipped places, due to impact from trays etc.

No. 56.d Animal room. "Clean room" at National Institutes of Health, Bethesda, Md., 1963-1968. Concrete slab on grade.

Fiberglas-reinforced epoxy trowel-on coating in good condition after 5 years service.

No. 48. Walk ramp outside Commissary, Fort Myer, Va., 1967

Non-slip trowel-on epoxy coating was in good condition after 8 months service but somewhat worn and smooth in traffic areas.

Thinset terrazzo epoxy coatings

No. 20. Photographic laboratory at Fort Belvoir, Va., Concrete slab on grade.

New installation (January, 1968) in area about 15- by 25-ft.

No. 55. Animal operating rooms and hall at National Institutes of Health, Bethesda, Md., 1963-1968.

Epoxy terrazzo with granite chips in good condition after 5 years service.

No. 56.b. Animal room. "Clean room" at National Institutes of Health, Bethesda, Md., 1963-1968. Concrete slab on grade.

Epoxy terrazzo with granite chips in good condition after 5 years service.

POLYESTER COATINGS

Trowel-on industrial type

Nos. 31-35, incl. Five barracks latrines and shower rooms at Fort Benning, Georgia, 1966-1968.

All floors were in satisfactory condition after about one year service.

Nos. 40, 41. Two barracks latrines and shower rooms at Fort Jackson, South Carolina, 1966-1968

Soon after installation, the floors appeared rough, porous, and stained; hard to clean. After sealing the floors were satisfactory and no trouble was reported during the first year of service.

Nos. 3b, 3c. Laundry at Fort Belvoir, Virginia. Two sections, each between washers and driers. 1963-1968. Concrete slab on grade.

The old concrete floor was acid washed; cleaned with detergent; rinsed with water; and dried with a torch. The primer was applied with a rubber squeegee. When the primer was still tacky, a 1/4-inch layer of green polyester mix was applied. After five years the floor was still in good condition, although dirty and faded in color.

No. 39. Laundry at Fort Dix, New Jersey, 1965-1967. Concrete slab on grade.

Floor in good condition after two years service.

No. 38. Meat cutting plant at Fort Dix, New Jersey, 1965-1967. Concrete slab on grade.

The coating was loose and peeling off after two years service, although the same materials and application method was used as in the laundry, No. 39.

No. 7. Mess hall kitchen at Fort Belvoir, 1967-1968.

An epoxy coating had been applied to the concrete floor; the coating had lost bond and became worn and was removed. A trowel-on polyester coating was applied about 4-6 weeks before the inspection. The finish was smooth and looked like a good job.

No. 13. Mess hall kitchen at Fort Belvoir, Virginia, 1965-1968.

The concrete floor was installed in 1958 and in 1965 was in good condition. There was some spalling around the drain and dishwashing areas and a few cracks and spalling on the pad under the ranges but no major cracks. The floor was prepared by acid wash; scrubbing with steel wool pad; scarifying with a machine; another acid wash; and a hose rinse. A polyester primer was placed on the concrete, with a little sand sprinkled on the wet primer. The final polyester coating was placed 1/4-inch thick and was white with green and black chips. After three years service the floor was in excellent condition.

No. 37. Mess hall kitchen at Fort Benning, Georgia, 1967.

After about six months service the floor was in good condition but rough and uneven and with indentations, all this attributed to poor troweling.

No. 27. Mess hall kitchen at Fort Benning, Georgia, 1966-1968.

A 1/4-inch polyester coating was troweled on over concrete. After 1-1/2 years service no defects were reported.

Polyester thinset terrazzo

No. 10. Mess hall kitchen at Fort Belvoir, Virginia, 1967-1968.

After six months service the floor was in excellent condition, smooth and clean looking.

No. 61. Meat cutting plant, Walter Reed Army Medical Center Annex, Forest Glen, Maryland, 1966-1967.

After about three months service the floor was in excellent condition.

No. 59. Concrete sun deck in hospital at Walter Reed Army Medical Center, Washington, D. C., 1966-1967.

The sun deck roof was first refinished with a concrete topping and then covered with a 1/4-inch thick polyester thinset terrazzo. After 16 months the deck covering was in good condition but with long structural cracks, repaired with calking compound, and stained with rust from a downspout.

No. 18. Salt spray room, Materials Research Laboratory, U.S. Army Mobility Research and Development Center (formerly ERDL), Fort Belvoir, Virginia, 1967-1968.

The concrete floor was cleaned, acid etched, and rinsed. A polyester primer coat was applied, then the resin topping, the same day. The topping consisted of resin, catalyst, marble dust, and crushed granite. The mix was troweled on to about 1/4-inch. About half the thickness was removed with a terrazzo grinder. After 8 months service the floor was in satisfactory condition but rather dirty.

No. 62. American Airlines Terminal at Washington National Airport, 1968.

Newly installed 1/4-inch polyester terrazzo over concrete was still dusty and subjected to building finishing operations.

POLYURETHANE COATINGS

Brush-on or Roll-on Coatings

Nos. 23-26, incl. Four barracks latrines and shower rooms at Fort Benning, Georgia, 1966-1967.

After about one year service most of the floor, in each case, was in good condition over most of the area but there were loose places and blisters at various positions, especially around the drains and toilets.

No. 30. Barracks latrine at Fort Benning, Georgia, 1966-1967.

After ten months service the floor was rough but satisfactory.

No. 42. Laundry at Fort George G. Meade, Maryland

a. Area next to windows between washers and driers

(1) First installation, January - May, 1964

The concrete floor was cleaned very thoroughly with caustic; the loose concrete was removed; and the floor thoroughly dried. Holes were filled with a polyurethane coating containing a small amount of sand. Four coatings were applied with a roller, sprinkling the last two with sand. The total thickness was then about 3/16-inch. The coating began to lose bond around the edges after about six weeks and was removed after about four months because of bond failure.

No. 56.c. Animal room. "Clean room" at National Institutes of Health, Bethesda, Maryland, 1966-1968. Concrete slab on grade.

A one-component polyurethane composition, two coats, was applied over a similar coating in 1966. The appearance was gray and shiny. The floor was in good condition after two years service.

No. 47. Stairs outside barracks at Fort Myer, Va., 1966-1967. Steel stairs outside brick building covered with concrete roof.

A polyurethane brush-on coating with fine stone aggregate in blue, white and black colors was used on the steel stairs from the first to the second floor. This was applied to the treads, a thicker layer being used on the upper part of the stairs. Soon after application, some wear was noticeable, especially on the lower part of the stairs, where the paint was worn off the steel nose pieces and considerable metal was worn away. There was less wear on the upper part of the stairs, where the steel nose pieces were scarcely worn and the white paint was still intact. After about 18 months service the stairs were still in satisfactory condition.

No. 58. Glassware washing facility at the Institute of Research, Walter Reed Army Medical Center, Washington, D. C., 1966-1967. Concrete slab on grade.

The floor had been covered with asphalt or vinyl asbestos tile, using asphalt adhesive. The tile and mastic were removed and decorative polyurethane brush-on coating was applied. The coating consisted of a primer and three finish coats, with vinyl chips. Some sand was broadcast on the surface before complete setting or hardening to skidproof the coating. The new floor was subjected to pipe-fitting operations. After about 18 months the floor was serviceable but unattractive. The floor was stained in places with dye. One place was etched and discolored with sulfuric acid-dichromate mixture used to clean laboratory glassware. The floor was hard to clean and the finish was worn and dull.

No. 49. Fire station at Fort Myer, Va., 1966-1967. Concrete slab on grade.

Holes in the concrete floor were patched with concrete and troweled. The floor was acid washed and cleaned with alkaline detergent. An epoxy based primer was then applied and then three coats of urethane based finish. Reclaimed vinyl chips were used as a filler. The first coat was sanded. The total thickness was between 1/16 and 1/8 inch. After about two months the coating yellowed at the entrance where it was exposed to direct sunlight. The floor also showed damage from sharp edges of trash cans, although it was not affected by pick-up trucks being driven over it. After about 19 months the floor showed more impact damage and it was necessary to apply a fresh seal coat.

No. 21. Entrance - Stair landing between outside door and door to inside corridor, Office building, Fort Belvoir, Va., 1967-1968.

A polyurethane brush-on decorative coating with vinyl chips was applied to the concrete floor. After about three months service the floor was in serviceable condition but looked slightly worn and dirty in traffic areas.

Nos. 52, 53. Residences - two houses used as family quarters at Fort Myer, Va., 1966-1967.

Polyurethane brush-on decorative coating with vinyl chips was applied over vinyl asbestos tile in the kitchens of the two homes. Clear polyurethane finish was applied to the wooden floors. After about 16 months service all floors were in good condition.

No. 60. Recreation building, Walter Reed Army Medical Center Annex, Forest Glen, Md., 1966-1967.

A polyurethane decorative coating was applied over 1/2-inch particle board, laid over a wooden floor, using a primer and three coats. After about a year service the floor was worn in places and there were some cracks, with evidence of peeling adjacent to the cracks. The floor was rather dirty, probably due to poor maintenance.

No. 9. Mess hall kitchen at Fort Belvoir, Virginia, 1967-1968.

After about one year service most of the floor appeared to be in satisfactory condition but a number of small places around the dishwasher, drain, and hot water heater had become loose and were cut out to replace with epoxy composition.

No. 42. Laundry at Fort George G. Meade, Maryland

a. Area next to windows between washers and driers

(2) Second installation, May, 1964 - November, 1966

A coating of 1 part sand to 3 parts epoxy resin was rolled on the cleaned concrete. Then two successive coatings of polyurethane resin were applied. Then a white, pigmented polyurethane composition was troweled on. After drying, this was wetted with solvent to make it tacky. Finally a polyurethane mix with walnut shell filler, brick color, was troweled on to 1/4-inch thickness. After about two years service the coating became soft, disintegrating, loose, and was peeling off in large sections. Pools of water were standing on the uneven floor.

b. Third bay from the windows

(2) Second installation (The first installation, 42.b.(1), was an epoxy coating), 1964-1966.

The coating was applied in the same manner and with the same composition as the second installation in the bay next to the windows, 42.a.(2) except that the test color was white and the mix had a sand filler. This disintegrated and peeled off during about two years service.

VARIOUS RESIN COATINGS

Nos. 28, 29. Two barracks latrines and shower rooms at Fort Benning, Georgia, 1965-1968.

Vinyl-acrylic coatings, about 1/16-inch thick, were in satisfactory condition after three years service except for peeling around the drinking fountain in the latrine in one of the barracks and peeling in the back part of the shower room in the other barracks.

No. 56.e. Animal room. "Clean room" at National Institutes of Health, Bethesda, Maryland, 1963-1968. Concrete slab on grade.

A vinyl trowel-on composition was in good condition after five years service.

No. 3.a. Laundry at Fort Belvoir, Virginia, section next to windows, 1963-1964.

Trowel-on furan coating was removed after one month service.

CONCRETE FLOOR TOPPINGS VASED ON PORTLAND CEMENT AND ADDITIVES

Acrylic latex additives

No. 8. Mess hall kitchen at Fort Belvoir, Virginia, 1959-1968.

After 9 years service the floor was in fair condition except for disintegration, roughness, and worn appearance around the floor drain and sink and a number of ine cracks all over the floor. The floor was dirty and hard to clean.

No. 51. Mess hall kitchen at Fort Myer, Virginia, dishwashing area, 1967. Concrete slab, 4 inches thick, over a wooden subfloor.

The floor is subjected to hand trucks. The surface was chipped in heavy traffic areas and was dirty but otherwise in satisfactory condition.

Styrene-butadiene additive

No. 11.a. Mess hall kitchen at Fort Belvoir, Virginia. First installation, 1960-1961.

The coating was removed after five months service.

Asphalt additive

No. 45. Storeroom at Fort George G. Meade, Maryland, 1966. Concrete slab on grade.

The topping was applied over rough, spalled concrete. After a few weeks service, while fork lift trucks were operating over the floor, the topping was in good condition except for some gouges.

No. 46. Plumbing shop at Fort George G. Meade, Maryland, 1964-1966. Concrete slab on grade.

After two years service the floor was in good condition except for some structural cracks.

CONCRETE FLOOR TOPPINGS BASED ON ALUMINA CEMENT AND NEOPRENE LATEX ADDITIVE

No. 36. Mess hall kitchen at Fort Benning, Georgia, 1966-1968.

After one year service the floor was in good condition.

Nos. 16, 17. Showers and dressing rooms in hospital, Fort Belvoir, Virginia, 1960-1966.

The floors were in service for about six years and the space was then converted to classrooms.

No. 22. Bakery at Fort Benning, Georgia, 1966-1967.

After about three months there were some breaks in the floor and evidence of crumbling in the coating. The floor was removed and the concrete scarified, then the same material was applied again. After about three months there were several loose places and some flaking. Most of the floor appeared to be in satisfactory condition.

No. 54.a. Intensive Care Unit and b. Circular Operating Wing, Clinical Center, National Institutes of Health, Bethesda, Maryland, 1964-1968.

The floors were reported to be in satisfactory condition after about four years service.

No. 57. Operating suite, National Naval Medical Center, Bethesda, Maryland, 1963-1968.

Conductive neoprene latex terrazzo floor topping was installed in January, 1963. After about five years the conductivity has remained about the same. The floors look dull. In the operating rooms there is some pitting in the middle of the room where the operating table is placed. There were also gouges in the corridor near a steel nose piece.

No. 56.g. Center corridor between animal "clean" rooms at National Institutes of Health, Bethesda, Maryland, 1963-1968.

The floor appeared to be in good condition after five years service.

RESILIENT FLOOR COVERINGS

Vinyl sheet good with welded seams

No. 56.a. Animal room. "Clean room" at National Institutes of Health, Bethesda, Maryland, 1963-1968. Concrete slab on grade.

The floor was in good condition after five years service.

Polyester tile

No. 19. Entrance between outside door and laboratories, next to stairs, at Fort Belvoir, Va., 1967-1968.

Polyester tile was installed on the concrete floor, using a 3/32-inch layer of adhesive, applied with a notched trowel. The new installation had cracks between the tiles and some tiles were higher than others, indicating an uneven subfloor. After about 8 months service, most of the tiles appeared tight superficially but, on close inspection, some tiles near the staircase were loose at the corners. There were cracks between the tiles. The tiles seemed to have leveled off; they were all at the same level. The floor was rather dirty.

QUARRY TILE

With epoxy bed and joints

No. 6. Mess hall kitchen at Fort Belvoir, Va., 1959-1968.

The installation procedure was as follows:

1) The concrete floor was cleaned with hydrochloric acid.
2) Epoxy resin was brushed into the concrete as a binder.
3) A bed of epoxy mortar and hardener was laid 5/8 to 3/4 inch thick.
4) Abrasive quarry tile, 6- by 6- by 1/2-inch, was set down, not pressed into, the bed.
5) The joints were filled with epoxy mortar.

In about six months some tiles were loose at the corners near the range. The epoxy bed and joints gradually disintegrated under the stoves and hot water heater. After about five years the tile on the range pads was replaced, using cement mortar. The epoxy under the hot water heater was mostly gone. After about 8 years service the black epoxy joints were worn and there were some holes.

No. 11. Mess hall kitchen at Fort Belvoir, Va., Second installation, 1961-1966. Plywood subfloor.

A latex floor topping had been removed after five months service. Then non-skid red quarry tile was installed, using epoxy bed and joints. The installation steps were as follows:

1) A plywood subfloor was installed with 1/4-inch joints between sheets.
2) An epoxy mortar was applied to the plywood subfloor with a notched trowel to 1/4-inch thickness, working the mortar into the plywood joints.
3) The quarry tile was set into the bed, leaving 1/4-inch joints.
4) The joints between the tiles were filled with the mortar used for the bed. The surface was then squeegeed and the excess removed with the rubber squeegee. The surface was finally cleaned with wet rags and sponge.

After five years service the joints were in good condition. The tile was in good condition except for some broken by impact, two around the center of the kitchen, one near the stove, and several near the floor drain. Apparently this tile was not affected by heat.

With furan bed and joints

No. 12. Mess hall kitchen at Fort Belvoir, Va. 1957-1968.

Red quarry tile was installed over plywood. After about ten years the building was closed and broken tiles were being replaced. Several tiles had cracked from impact.

No. 14. Mess hall kitchen at Fort Belvoir, 1955-1958.

Quarry tile, 1/2-inch thick, was installed over plywood. After about 13 years service the floor was in excellent condition except for a few cracked tiles.

No. 15. Mess hall kitchen at Fort Belvoir, Va., 1957-1968.

Quarry tile, 1/2-inch thick, was applied over plywood with "Miracle" adhesive and furan mortar joints. The workmanship was poor; the adhesive was not spread thoroughly over the plywood and the joints looked sloppy. After about three months about 24 tiles cracked, probably due to impact from heavy trash cans; otherwise the installation was satisfactory. After ten years the tiles were badly cracked. Finally the broken tiles were replaced where damaged by trash cans, using portland cement grout.

ERRATA

Table 1. Under Epoxy monolithic and Polyester monolithic the following columns should read:

	Total	Failures	Fairly Satis.
Epoxy monolithic - all types.....	14	5	3
Brush-on, roll-on.....	2	1	
Trowel-on industrial.....	9	4	3
Thinset terrazzo.....	3	1	
Polyester monolithic - all types.....	21	2	5
Trowel-on industrial.....	16	2	3
Thinset terrazzo.....	5		2

Table 2. No. 1. should read: Type of floor covering

Trowel-on polyester monolithic

Table 4, page 1 - Under EPOXY COATINGS,

Trowel-on industrial type. Omit No. 1. Barracks latrine at Fort Belvoir, Va.

page 3, under POLYESTER COATINGS

Trowel-on industrial type, insert:

No. 1. Barracks latrine at Fort Belvoir, Va. 1968. Concrete slab on grade.

A previous epoxy coating was removed, revealing old paint and a rough surface in the center of the room. A trowel-on polyester coating was applied to the floor apparently while the room was cold (poorly heated during January). After about a week there were blisters and cracks all over the floor.

Table 4, page 5. No. 62. Change to read: Newly installed 1/4-inch polyester terrazzo over new concrete was still dusty and subjected to building finishing operations.

Table 4, page 7. No. 9. Change to read: .....a number of small places around the dish washer, drain, and hot water heater had become loose and were patched.....

Table 4, page 10, under Polyester tile, No. 19. Change to read:

.....some tiles near the staircase in low traffic areas were loose at the corners.....


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